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Barrier-Protected Container

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This invention relates to a structure, useful for storage or accommodation, comprising a freight container clad internally and/or externally with a barrier structure constructed from panels of reinforced matrix material.

Background to the Invention

There is a need for blast and/or ballistic (i.e. projectile) impact resistant storage or accommodation structures for use in battle zones or in locations near explosive hazard sites. One known type of structure comprises a metal container which is encased in poured concrete. According to European Patent Application EP-A-0233808, the metal container encased in this way may be a standard freight container (also called a shipping container) of the kind which is familiar for being transported on the trailer of an articulated road vehicle, on a rail wagon, on the deck of a container ship, or in the hold of transport aircraft.

Encasing a freight container in concrete has some drawbacks. For example, the container must be placed in a hole in the ground and the concrete poured into the hole, or formwork must be erected around the container to contain the poured concrete; it is often difficult to mix on site the large quantities of concrete required; the resultant encased structure is extremely heavy; poured concrete requires many days to harden to the extent necessary for blast or ballistic protection; and it may be difficult or impossible to arrange reinforcement in the concrete in optimal configuration.

Description of the Invention

The present invention aims to provide an alternative type of blast and/or ballistic resistant structure which is more convenient, more reliable and lighter than concrete encased freight containers.

According to the invention, there is provided a structure comprising a walled freight container enclosing an interior volume of space, the container being at least partially clad internally and/or externally with a barrier structure, the

barrier structure comprising a single panel or a plurality of panels of matrix material incorporating reinforcement elements, and means for human entry into and exit from the interior space of the container being located in a wall of the container and, if necessary for such entry and exit, also in the barrier structure.

As used herein, the terms "walled freight container" or freight container" or "shipping container" or "transport container" all refer to the reusable articles of transport equipment in common use for transporting goods intranationally and internationally by road, rail, sea and air, liftable by mechanical aids such as grappler arm and fork lift machinery, particularly to transfer the container from one mode of transport to another.

Generally, the barrier structure will take the form of a wall or walls.

A preferred embodiment of the invention is a structure comprising a freight container in the form of a six-sided box having top, bottom, side and end walls, one end wall incorporating at least one door, at least the top, side and end walls including the door thereof being clad internally of the container with a barrier structure comprising a plurality of interconnected panels of matrix material incorporating reinforcement elements, the panels being fixed to the container walls, the structure being transportable as a unit.

The matrix material of the panel(s) of the barrier structure may be cementitious, ceramic, metallic or resinous. Cementitious matrix materials will often be preferred. An example is the DSP ("Densified systems with ultrafine Silica Particles") matrix materials disclosed, e.g., in US Patents Nos. 5,234,754 and 4,588,443 which are based on dense packing of cement particles with ultrafine silica fume particles in interstices between the cement particles. These binder matrices, e.g. mortar matrices, are made from a mix containing cement particles, ultrafine silica particles of a size which is typically about 1/100 of the size of the cement particles, water in a low amount relative to the cement plus silica, a concrete superplasticizer as dispersing agent, and

sand and stone particles as additional bodies, often with added fibres such as steel.

The reinforcement elements present in the matrix material of the panel(s) of the barrier structure will often be of two geometric types, namely (a) elongated or sheet-like main reinforcement elements, generally orientated in the plane of the panel, and (b) secondary compact shaped reinforcement elements distributed in the matrix material surrounding the main reinforcement. In this context "compact shaped," means shapes capable of fitting into domains of matrix material not occupied by the main reinforcement. Preferably both types of reinforcement (a) and (b) are present. Both types of reinforcement will normally be embedded in the matrix material of the panel, but this does not preclude parts of the reinforcement elements being exposed at the surface of the panel(s). The main reinforcement may be shaped as rods, wires, cables, interlacings of rods and/or wires and/or cables, meshes or nets, sheets or plates, or perforated sheets or plates. The main reinforcement may be of steel, titanium alloys, carbon fibre, Aramid (Kevlar) fibre, or a composite material such as fibre-filled resin. The secondary reinforcement may be shaped as lumps, for example of stone (including bauxite and korund) or metal, fibres, for example fibres of metal, carbon or synthetic resin, whiskers i.e. a plurality of fibres bundled together, and flake materials, for example of metal or stone. A hard coating may be applied to the reinforcing elements.

The barrier structure will preferably be designed to resist damaging perforation, translation, rotation and deformation under blast and/or ballistic impact forces. It may then serve to protect the interior of the container from the full extent of blast and/or ballistic impact forces applied externally to the overall structure, or to protect persons or objects outside the overall structure from the full effects of an explosion within the interior of the container. Thus, in one embodiment, the panel or panels of the barrier structure are supported by panel support means for reducing the deformation of the barrier structure in the direction of the interior of the container when the barrier structure is subjected to a force applied in that direction.

Many types of panel support means may be envisaged. The panel support means may simply be areas of the panel(s) which are locally thickened, for example to form a rib or pattern of ribs standing proud from one or both faces of the panel(s). The panel support means may also be constituted by locally densified and/or additionally reinforced domains of the panel(s). Such locally densified and/or reinforced areas may be regarded as “internal rib elements” forming an integral part of the panel(s).

Alternatively, the panel support means may be rib elements separate from the panel(s) but abutting, fixed to, or partially embedded in one or both faces of the panel(s). Such separate rib elements may be arranged in an interconnected grid, for example by being welded or bolted to one another, to form a rib lattice abutting, fixed to, or partially embedded in one or both faces of the panel(s). Separate ribs on each side of the panel(s) may be interconnected, for example by bolts extending through the panel(s). Furthermore, interconnection of separate ribs or rib lattices on adjacent panels may be the means, or part of the means, of interconnecting adjacent panels.

Another form of panel support means may be a network of rods, wires or cables abutting, fixed to, or partially embedded in one or both faces of the panel(s), or extending through passages formed in the panel(s) coplanar with the faces of the panel(s). Such rods wires or cables are preferably prestressed.

In most cases, the barrier structure will comprise a plurality of interconnected panels, which may be interconnected by discrete interconnection elements, or by means integral with the panels. Many types of interconnection means may be envisaged, but they may be considered as falling into two categories, namely those which connect adjacent generally coplanar panels, for example to form a wall, and those which connect panels at an edge along which the panels meet at an angle, for example a right angle.

In the case of the former type of connector, integral interconnection elements may be provided by matching profiles, for example tongue and groove profiling, or interlocking rebate profiling, along panel edges to be interconnected. Separate interconnection elements may be, for example, elongated plane metal forms such as an elongated flat metal plate running along the abutting edges of a pair of in plane panels, clamping the panels by means of bolts passing through the panels and plate. They may also be profiled metal forms having grooves running the length of each form, for example I- or S- profiled forms, such that the panel(s) slot into the grooves. Several such grooved forms may be welded into a lattice to receive and interconnect a plurality of panels.

In the case of the latter type of connector, integral interconnection elements may again be provided by matched profiling, for example interlocking rebates, or mitre profiles running the length of the edges to be interconnected. Matrix material binder may be applied to the abutting rebates or mitres to strengthen the joint. Retaining pins through the rebate- or mitre-abutted edges may also be inserted to strengthen the joint. Alternatively main reinforcement embedded in one or both of the abutting panels, for example rods embedded in the matrix material of the panel(s), may be inserted into matching recesses in the other panel(s), and if desired the projecting reinforcement may be sealed into the matching recesses with matrix material binder. Separate interconnection elements may be provided by, for example, elongated angle-profiled metal forms which clamp the angled abutting edges of the panels by means of bolts passing through panels and the metal form. Alternatively, the angle-profile forms may have grooves running the length of each form, such that the panel(s) slot into the grooves at the desired angles.

Any panel support means and/or discrete panel interconnection elements as discussed above may be formed from materials which are suitable for use in the anticipated high stress conditions of use of the structure of the invention. Metals, principally steel, will often be the preferred materials, but often matrix material incorporating reinforcement elements will also be suitable. In such

cases, the matrix material and the reinforcement may be of the kinds discussed above in relation to panel matrix materials and reinforcement.

The weight of the overall structure may be supported in various ways, depending on the structure's orientation. For example external side panels of the barrier structure are preferably provided with means for anchoring them in the ground, such as retaining flanges, piles or spikes, which may be bedded in matrix material such as concrete or the matrix material of the panels. In that case, the panel(s) of the barrier structure may sit directly on, or be clamped by, the flanges, piles or spikes, or a rail may be supported on, or clamped by, the flanges, piles or spikes and the panels may sit on, or be clamped by, that rail. Alternatively, transverse beams may pass through the container adjacent its floor, and these beams may support the side panels of a barrier structure located internally or externally of the container. Such beams may also be anchored in the ground in the manner mentioned above. If the barrier structure protects the bottom wall of the container, its panel(s) may be supported by beams as just mentioned, and any side panel(s) of the barrier structure may be supported by the bottom panel(s)s or by those beams. Likewise, if the barrier structure protects a top wall of the container, its panel(s) may be supported by bolts connecting the panels to the roof wall of the container, and/or by beams passing through the container adjacent its top wall, and/or by any side panel(s) of the barrier structure.

Means for anchoring the overall structure of the invention in the ground impart stability to the structure as a whole, and provide means for diverting some of any blast and/or ballistic impact forces away from the container. Many different anchoring means may be envisaged. Flanges, piles or spikes have already been mentioned above, and these may be provided with barb elements to resist extraction from the ground or the matrix base in which they are embedded. The structure may be bolted to concrete base on which the structure sits. Steel cable guys or high tensile strength straps may be stretched over or fixed to the structure and anchored in the ground, or in a concrete base. The structure may be buttressed by buttresses anchored in the ground or in a concrete base. The structure may be clamped to the ground by

L-shaped beams, the short leg of which extends over and abuts the top of the structure, and the long leg of which extends down the side of the structure into the ground or into a concrete base. The structure may be partly or completely buried in the ground. Burying or partial burying may be mimicked by sandbagging the structure completely, or circumferentially to any desired height or thickness.

To provide additional resistance to deformation and/or perforation by blast and/or ballistic impact forces (i.e. additional to that provided by any panel support means, panel interconnection means and ground anchoring means), a face of the barrier structure facing the anticipated direction of any blast and/or ballistic force may be clad with sheet, plate or tile elements, for example of metal or ceramic materials. In most cases the purpose of the barrier structure will be to protect the interior of the container, so it will be the face or faces of the barrier structure facing away from the interior which may be clad in this way.

The container is clad by the barrier structure in the sense that at least part of a wall of the container is shielded internally or externally by an associated part of the barrier structure. In practice, in the case of both internal and external cladding, the cladding barrier structure will often be fixed, for example by bolts, to the container walls and will either abut the walls directly or indirectly via an intermediate layer, for example of insulating or shock absorbent material. In some cases it may be preferable to allow for a gap between a wall of the container and its barrier structure cladding. Such a gap allows the barrier structure to deform under blast and/or ballistic impact loads, without forcing corresponding deformation of the wall of the container. The gap may be bridged by filler material, for example of foamed, particulate or fibrous material, which may serve as heat and/or sound insulation and/or as a means of absorbing some of the deformation forces from a deforming barrier structure. In some cases, discrete connector elements interconnecting the container wall and barrier structure may bridge any gap, and these may connect the barrier structure to a rigid part of the container such as an edge or corner where container walls meet.

The container will usually have generally planar (including corrugated planar) side, top and bottom walls, A particularly suitable freight container is the standard, closed, general purpose, 6-sided box-shaped freight container, which has an access door or doors in one side wall, usually a rear end wall, and which often has integral means for facilitating mechanically aided lifting, such as fork-lift pockets, fixtures for handling by grappler arm, or gooseneck tunnels. Such freight containers are alternatively known as shipping containers. The International Organisation for Standards has described freight containers as articles of transport equipment (a) of a permanent character and accordingly strong enough to be suitable for repeated use; (b) specially designed to facilitate the carriage of goods by one or more modes of transport, without intermediate reloading; (c) fitted with devices permitting its ready handling particularly its transfer from one mode of transport to another; (d) so designed as to be easy to fill and empty. Standards (ISOs) issued from time to time by the International Organisation for Standards relate to aspects of the design of freight containers, examples being ISO 668 and ISO 1496-1.

Since the function of the barrier structure is to defend the interior of the container from blast and/or ballistic impact forces, or to protect persons or objects outside the container from the effects of an explosion within the container, it will normally be coextensive with at least one side wall of the container, normally the wall facing the expected force. Preferably, however, the barrier structure will be substantially coextensive with all side walls of the container and/or with a top wall of the container, and/or with a bottom wall of the container. In one particular embodiment, each panel of the barrier structure is substantially co-extensive with a wall of the container. In another embodiment at least the side walls (including any door(s) into the interior of the container) and the top wall are clad internally of the container with a barrier structure consisting of a plurality of interconnected reinforced panels.

In a special structure of the invention the freight container comprises an inner and an outer wall, and the barrier structure is interposed at least between the inner and outer walls.

The wall(s) of the container must be provided with access for humans such as a hatch or door. It follows that the barrier structure must also be provided with such access, if necessary to reach the container wall access. In many cases, when the structure of the invention sits on the ground, the container wall access may best be located in a side wall. Access (which may be openable and closable) may be provided via a hinged or sliding door in the container wall clad with barrier structure as for any part of the container wall. In either case, the access area through the barrier structure may be defended by a shielding part of the barrier structure or a separate access-shielding barrier structure.

One advantage of many of the embodiments of the invention is that the structure is transportable as a unit by road, rail, sea, or air. Furthermore, the structures of the invention may be conveniently grouped in a desired relationship with each other. For example two or more containers may abut each other, possibly with interconnecting access, the non-abutting walls being clad with a barrier structure as described above.

Embodiments of the invention will now be described by reference to the accompanying drawings wherein:

Fig 1A. is an external view of one type of walled freight container suitable for protective cladding in accordance with the invention.

Fig 1B is an exploded view of the freight container of Fig 1A omitting one of the side walls.

Fig 1C is a view of the box frame from which the walls of the container of Figs 1A and 1B are hung.

Fig 1D shows an assembly of planar-faced panels for cladding the interior of the container of Figs 1A, 1B and 1C.

Fig 1E shows a joint between edge-abutting in-plane panels of the Fig 1D assembly.

Fig 1F shows a joint between right angle edge-abutting panels of the Fig 1D assembly.

Fig 1 is a partially cut away, partially exploded perspective view of a freight container externally clad with a barrier structure to form a structure in accordance with the invention.

Figs 2 - 6 illustrate panel support means for supporting a panel of a barrier structure for use in accordance with the invention.

Fig 7 illustrates means of mounting the barrier structure to integrate it with the container.

Figs 8 – 13 and 13A illustrate connector means for connecting panel edges such that the connected panels are at an angle to each other.

Figs 14A-14Q illustrate connector means for connecting panel edges such that the connected panels are substantially coplanar.

Figs 15A-15E illustrate various means of arranging the panels of the barrier structure in relationship to the container wall which they clad.

Referring to figs 1A, 1B and 1C, a typical design of standard freight (or shipping) container 100 is shown. This design is only one of several which are in routine use in national and worldwide transportation, by road, sea and air. Such containers are suitable for protective cladding in accordance with the invention.

The container 100 is a six-sided steel box, with a roof or top wall 102, a floor wall 103, two side walls 104 (one of which is omitted for clarity in Fig 2B, an end wall 106 and two hinged doors 107a and 107b hung from a door frame

107c forming another end wall, providing access to the interior of the container. The walls are hung from a box frame structure 108, made up of bottom side rails 109 and 110, top side rails 121 and 122, top end rail 123, door header rail 124, door sill 125, corner posts 126, and bottom end rail 127, with corner fittings 128 at each corner. The bottom side rails 109 and 110 are interconnected by box-section beams 111 and 112 forming forklift pockets 113 and 114, and by cross members 115, all lending rigidity and strength to the structure, and to the floor in particular. Flooring 116 is laid over the cross members 115 to provide a continuous floor surface. The top wall 102, side walls 104, end wall 106 and doors 107a and 107b are all corrugated for rigidity. The doors are hinged from the corner posts 126 of the rear end frame 107c, and are secured in the closed position by a sliding bolt assembly 119. In the version shown, a ventilator opening 120 is provided in at least one wall.

In accordance with the invention, a freight container such as that shown in Figs 1A, 1B and 1C is at least partially clad internally and/or externally with a barrier structure, the barrier structure comprising a single panel or a plurality of panels of matrix material incorporating reinforcement elements. In a simple embodiment, one or more walls of the container may be clad internally of the container by reinforced panels bolted to the relevant wall(s) and interconnected at their abutting edges.

Thus Fig 1D shows a barrier structure comprising an assembly of planar-faced panels 121 of cementitious matrix material in which is embedded secondary reinforcement such as stone aggregate and steel fibres, as well as main reinforcement such as longitudinally and possibly also horizontally extending steel rods. The panels and the assembly as a whole are shaped and sized to clad the top wall 102, side walls 104 and 105 and end wall 106 internally of the container. Not shown are the suitably sized panels which also clad the internal sides of the doors 107a and 107b. Thus, in this embodiment, all interior walls of the container are clad by reinforced panels 121 except the floor. However, in other embodiments other cladding patterns are possible, including the cladding of all six walls.

Fig 1E shows a two edge-abutting in-plane side panels 121a and 121b of the assembly of Fig 1D, joined by a steel plate 122 extending the length of the abutting edges. The panels 121a and 121b are clamped securely to a side wall 104 of the container by nuts and bolts 123a and 123b, the bolts passing from the exterior of the container through the side wall 4, the panels 121a and 121b, and the plate 122. A strip of high strength steel 124, for example Hardox 600, is welded to the plate 122 along its length to add strength to the joint and increase resistance to blast and projectile impact.

Fig 1F shows two right angle-abutting panels 121c and 121d of the assembly of Fig 1D, joined by a steel angle plate 125 extending the length of the joint. Here also, the panels 121c and 121d are clamped securely to, in this case, a side wall 104 and a top wall 102 of the container by nuts and bolts 123c and 123d, the bolts passing from the exterior of the container through the side and top walls, the panels 121c and 121d, and the plate 125.

Many variations on the reinforced panel design and panel interconnections are possible, in order to maximise blast and projectile impact resistance. Some such variations are described below, in connection with the externally clad container embodiment of Fig 1.

Referring to Fig 1, the side and top walls of a six sided rectangular box container 1 are clad externally with a barrier structure 2, comprising a plurality of planar-faced panels some of which are shown at 3a, 3b, 3c, and 3d. The container is a standard freight container such as that shown in Figs 1A-C, modified to the extent necessary to accommodate the features of the invention described herein. The barrier structure 2 is coextensive with all four side walls and the top wall of the container, but for clarity parts are shown as cut away to reveal the underlying container. Also for clarity, the panel 3d of the part of the barrier structure which clads the top wall of the container is shown as separated from the side panels. The panels are formed from a cementitious matrix material in which is embedded secondary reinforcement in the form of stone aggregate and steel fibres, as well as main reinforcement in the form of horizontally and longitudinally extending steel rods, the

protruding ends 4 of which are seen projecting from the side panels 3a, 3b and 3c. Top panel 3d has matching holes 5 formed around its edges, into which the rod ends 4 fit when 3d is positioned on the side panels to provide a connection between the side and top panels.

The panels of the side and top walls are interconnected by I-profiled beams 6, into the side slots of which the panels fit, and are optionally fixed by cementing or with fasteners such as bolts or retaining pins. Panels 3b and 3c meet at right angles and are interconnected by a steel profile 8. Side panels 3a and 3b slot into and are optionally fixed in a Y- profiled metal beam 9, the bottom flange 10 of which is driven into the ground to anchor the overall structure. Not shown are similar Y-beams into which slot panel 3c and other panels forming the side walls of the barrier structure 2.

The bottom wall (i.e. the floor) of the container 1 is supported by I beams 11 which are preferably welded to the container bottom wall. The Y-beams 9/10 are preferably welded to the ends of the support beams 11 to integrate the barrier structure with the container and render it transportable as a unit. For that purpose, the corner metal profiles 8 may also be connected by welded brackets, not shown, to the, walls and/or corners and/or corner edges of the container.

A wooden or metallic framework 13 is shown attached to one side wall of the container in the gap between the panel 3c and the container wall, but is repeated (not shown) on the remaining side walls and the top wall. The framework 13 forms a support grid for foam, particulate or fibrous insulation, or other gap filler material.

The floor of the container has a trapdoor 12 which is accessed by a subterranean tunnel (not shown) for entry into and exit from the interior of the container.

Some or all of the panels 3a, 3b, 3c and 3d shown in Fig 1, and the remaining panels (not shown) of the barrier structure 2 may be provided with panel

support means to reduce deformation of the panels under blast and/or ballistic impact forces. Examples of various embodiments of panel support means are illustrated in Figs 2-6.

In Fig. 2, an example panel 23 is formed with locally thickened support ribs 21 standing proud of a face 22 of the panel. These ribs may be formed on casting the matrix material of the panel. The ribs may be of any desired cross section dimensions, and the composition of the ribs may be identical to that of the matrix material, of the panel, incorporating secondary reinforcement like stone aggregate and steel fibres, and (the dimensions of the ribs permitting) main reinforcement, for example in the form of steel rods or cables. The ribs will usually be formed on at least the face of the panel facing away from the expected direction of blast or ballistic impact force, but may be formed on either or both faces of the panels. When formed on both faces, the ribs of one face may be in direct opposition to matching ribs on the other face, or may be offset in opposition to the ribs of the other face. Where the structure of the invention is intended to protect the occupants from external forces, the support ribs will normally be formed on at least the face of the panel facing the container.

In Fig. 3, an example panel 24 has a steel support assembly 25 with support arms 27. The support assembly shown has an I-profile, with one flange 28 of the assembly abutting the face 26, but its cross sectional profile is not critical. For example the assembly might be formed from single or multiple box section tubes. The support assembly may be of any desired dimensions. Like the support ribs of Fig 2, it may abut either or both faces of the panel, but will usually abut at least that face which faces away from the expected source of the force. Again, when abutting both faces, the arms of the support assembly on one face may directly oppose, or may be offset in opposition to, the arms of the assembly abutting the other face. The assembly may be fixed in position on the panel face 26, for example by bolts (not shown), and where the assembly abuts both faces of the panel, they may be interconnected through the panel. In a variation of the embodiment shown in Fig. 3, the flange

28 of the support assembly 27 may be embedded in the matrix material of the panel, by casting the matrix material over that flange when forming the panel.

In Fig 4, the panel support means takes the form of steel cables or bundles of steel wires 30 held in tension in a grid arrangement adjacent a face 31 of an example panel 29. In the embodiment shown, the tensioned cables or wires 30 are stretched between the opposite sides of a rectangular tensioning frame of substantially the same dimensions as the wall of the container clad by panels 29, the tensioning frame being mounted around the perimeter of that wall of the container. In another alternative, the tensioned wire bundles or cables could pass through bores formed through the panel, coplanar with the panel faces, to form a panel support grid housed within the panel itself.

In Fig 1, panels 3a and 3b are shown as interconnected by the I-beam 6. This I-beam is an example of a panel interconnector which also functions as panel support means. Figs 5, and 6 illustrate other examples of dual function panel interconnector and support means. Thus in Fig 5, a steel support assembly 33 similar to assembly 25 of Fig 3, has an I-profile cross section, with flanges 38 and 39. Panels 35, 36 and 37 are shown fitted into the groove between flanges 38 and 39, and may be bolted in place or cemented in place by matrix material. The flanges 38 and 39 abut opposite faces of the panels 35, 36 and 37, and serve as panel support means as well as panel interconnectors. In Fig 6, the I-beam connector/support 6 is replaced by an S-beam 42, functioning as panel interconnector and support means, so that adjacent panels 40 and 41 are held and supported in overlapping relationship at their edges.

In the embodiment shown in Fig 1, the four side walls and the top wall of the container are clad with the barrier structure panels. In that embodiment there is no barrier structure cladding the bottom container wall (the floor), and the barrier structure is anchored in the ground by the flange 10 of the elongated Y-beam 9 The latter is welded to the ground-resting beams 11, which in turn are welded to the floor of the container. This is only one way of integrating the barrier structure with the container, in cases where the floor of the container is not clad. For example, the elongated Y-beam 9/10 of Fig 1 could be replaced

by a series of spikes with an upper U-shaped panel-retaining cup and a lower spike part, the latter being driven into the ground in the same way as the flange 10.

Fig 7 shows an alternative method of integrating the barrier structure and the container. Here a first external rectangular frame 50, for example of box cross section tubing, is welded around the outside base of container 51. Shipping containers are often built around an open box girder frame, with transverse beams bracing at least the bottom rectangular section of the frame, the walls of the container being fixed to the box frame as in the design shown in Figs1A-C. The external frame 50 may be welded to the container walls and/or bolted through the walls the box frame of the container. A second external rectangular frame 52 surrounds and is spaced from the first frame 50 by a gap 53. Panels 54 of the barrier structure are sandwiched in gap 53 between the first and second external frames 50 and 52. Bolts 55 pass through the second external frame 52, the panels 54, the inner external frame 50 and the wall of the container, to be secured in the interior of the container against the inner surface of the walls or the container's box frame. In this way the assembly of frame 52, panels 54, frame 50, and wall of container 51 are united as a composite unit. A similar sandwich of external frames and the panels may be mounted around the top of the side walls of the container. The undersides of frames 50 and/or 52 may be provided with spikes which are driven into the ground to anchor the structure.

The principle of mounting the panels of the barrier structure by sandwiching between base frames is applicable also when the barrier structure is mounted inside the container. In such interior-clad embodiments, the innermost frame may be replaced by a floor abutting the base of the panels. The panels are then be sandwiched between the floor and internal frame abutting the container walls. Such a floor may be of cast matrix material incorporating main and secondary reinforcement, or may be constructed from matrix material panels of the barrier structure.

In a variation of the "two frame sandwich" arrangement described above, the first external frame 50 may be omitted, and the base of the panels sandwiched between the outer external frame 52 and the container walls. A similar variant of an internally mounted barrier structure would sandwich the base of the barrier panels between the container walls and an inner frame or floor.

The above discussion of Figs 1 and 7 relate to embodiments of the invention where the bottom wall of the container is not clad with a barrier structure. In cases where a bottom barrier structure is present, it and the side panels of the barrier may be connected by connector means similar to that illustrated in Fig. 1 for connection of the top panels of the barrier to the side panels, i.e. by means of protruding main reinforcement and matching holes. However, many kinds of interconnectors for panels may be envisaged, both in the case where the panels are edge connected in the same plane and those where they are edge connected at an angle, usually a right angle. Some alternative panel connector means for angled connection are discussed below with reference to Figs 8 - 13, and for substantially coplanar connection with reference to Figs 14A-14P.

In Figs 8A and 8B, a top panel 55 or 55a and a side panel 56 or 56a of the barrier structure are frictionally mated at right angles via a rebate or rebates formed along one or both the mating edges. A layer of bonding material, which may be the matrix material of the panels, may be applied to the abutting faces of the rebates, to impart additional stability to the connection.

In Fig 9, top panel 55b and side panel 56b have main reinforcement in the form of steel rods, the protruding ends 57 of which are bent as shown. Binder material 58, which may be the same as the matrix material of the panels encases the interlaced rod ends 57 to consolidate the interconnection of the panels.

In Figs 10A-10F are shown variations of interconnection means wherein steel pins 59a-59f are inserted into holes 60a-60f provided in both panels 61a-61f

and 62a-62f extending through panels in the joint region The inserted pins are fixed in the holes with binder material, and in the case of Figs 10D and 10E binder material 63d and 63e is applied around the joint to consolidate it.

Fig 11 shows a variant of the pin and hole fixing of Fig 10, where the pins are formed by protruding main reinforcement 64 of the side panel 65, the protruding reinforcement bent for insertion into slots 66 formed in top panel 67. Again, the reinforcement is cemented in the slots by binder material, which may be the same as the matrix material of the panels.

Fig 12 shows a variant of the embodiments of Figs 9 and 10E, wherein main reinforcement 68 and 69 protrudes from side and top panels 70 and 71 respectively, and the protruding ends are bent as shown. Binder material 72 is applied in and around the interlaced protruding reinforcement to consolidate the joint.

In Fig 13, a suitably profiled steel form 73 accommodates top panel 74 and side panel 75, the panels being fixed in their respective slots of the profile, for example by retaining pins or bolts (not shown), or by matrix binder material.

IN Fig 13A, a corner piece 73a is formed from the same matrix material as the panels 74a and 75a, and incorporates main and secondary reinforcement Edges 73b/74b and 73c/75c of the corner piece and panels respectively are joined by any of the methods illustrated in Figs 14A – 14Q below.

In Fig 14A, two panels 80a and 81a, which are to be interconnected so that the panels are substantially coplanar, have main reinforcement steel rods 82a projecting from the panel edges to be joined. When the edges of the panels are brought together, the projecting rods intermesh. Matrix binder 83a is applied between the panel edges, around the intermeshed rods to make the joint.

In Fig 14B, one panel 80b has main reinforcement steel rods 82a projecting from the panel edge, while the other panel 81b has matching bores 83b

formed in its edge for insertion of the protruding rods 82b. The rods may be cemented in the bores with matrix material.

In Fig 14C, elongate steel rods 82c and steel bars 84c are bound with lacing elements such as steel wire into a composite keying block 85c. Opposed recesses 80c and 81c are formed in the panel edges, into which the composite keying block 85c fits when the panel edges are brought together. The keying block may be cemented in the panel edge recesses with matrix material. The keying block may extend along the length of the panel edges to be joined, or two or more such recessed keying blocks may be arranged along the panel edges to make the joint.

Fig 14D shows a variant of the interconnection of Fig 14A, wherein some of the protruding reinforcement rods 82d are arranged to mesh between the panel edges to be joined as in Fig 14A, and some, 83d, to extend over the surface of the panels adjacent the joint. Matrix material 84d is then filled into the joint and over the surfaces of the panels adjacent the joint to envelop the meshed and surface-extending rods, and thereby complete the joint.

In Figs 14E and 14F, the panels to be interconnected are positioned in the slots of elongated steel profiles 86e and 86f, and may then be fixed in place, for example by retaining pins or bolts, or by matrix material cement. In a variation of the interconnection pattern of Fig 14F, Fig 14G uses the same elongated steel profile 86g, but the panels are arranged in "venetian blind" pattern.

Fig 14 H shows two panels interconnected by inserting the edge of one panel into a matching cup form 86h moulded on the edge of the other panel during its casting, so that the two panels are jointed in "tongue and groove" fashion. The inserted edge may be fixed in the cup form with matrix material cement.

Figs 14I and 14J show the interconnection of panels using only binder 88i and 88j.

In Fig 14K panels are interconnected by inserting pins of steel rod 89k into bores 90k formed through overlapped panel edges. The pins may be cemented in place in the bores using matrix material.

In Fig 14L, A steel beam 90l is welded to a wall 91l of the container, and extends longitudinally in a gap between the edges 92l and 93l of the two example panels to be joined. In cross section the beam 90l has a plurality of longitudinal flanges or fins 94l. Binder material 95l surrounds the flanges 94l and fills the gap between panel edges 92l and 93l, completing the joint.

In Fig 14M, the edges of the panels to be joined have moulded protuberances 91m formed when the panels are cast, and the joint is made by the application of matrix material to envelope the protuberances as shown

In Figs 14N and 14O, the edges of the panels to be joined have interlocking male and female elements which may be cemented in place with matrix material.

In Fig 14P edge abutting panels 80p and 81p have bores 92p formed in the panels perpendicular to the panel edges to be connected. Tensioned cables or wire bundles 93p pass through the bores and pull the panels into tight edge contact. The wires are held in tension between tensioning bars 94p positioned in panel edge grooves 95p.

In Fig 14Q, rectangular steel plates 95q and 96q are cast into panels 90q and 91q via embedded flanges or spigots 97q and 98q, along the whole length of the panel edges to be joined. The plates are than bolted together by bolts 99q to complete the joint.

As stated above, the barrier structure included in the overall structure of the invention may be spaced from the wall of the container which it clads, or it may abut that wall. The barrier structure may or may not be interconnected to the wall of the container which it clads. Figs 15A –15E illustrate various configurations of these relationships.

In Fig 15A a panel 96a of the barrier structure is spaced from a wall 97a of the container (which is corrugated as in the case of a typical shipping container), and elongated H-profile beams 98a are welded or cemented by binder material to the container wall, horizontally and/or vertically. The panel abuts, but is not otherwise connected to the H-beams.

In Fig 15B, the panel 96b is interconnected to the container wall 97b by binder material 98b. The binder material may be the same as the matrix material of the panel. In a variation of this embodiment, bolts passing through optional spacer elements may be substituted for the binder cement, to fix the panel to the wall corrugations. In another variation of this embodiment, the panel simply abuts the wall, with no binder cement.

In Fig 15C, The panel 96c is maintained in spaced relationship to the wall 97c by U-profile beams or brackets 99c cemented or welded to the top and bottom edges, or side edges of the container wall. The spacing between panel and wall may be adjusted by spacing blocks positioned between the U-beams or brackets and the container wall.

In Fig 15D the thickness of the panel 96d is locally increased as stud or rib forms 101d. The studs or ribs abut the wall 97d, in this case along the corrugations extending nearest the plane of the panel.

In Fig 15E deformable spacer elements 102e are cast into the panel 96e during casting, and project from the panel face nearest the container wall 97e. These spacers abut the wall 97e and may optionally be cemented or welded thereto. Blast or ballistic impact load on the exterior panel face is partially transferred to the wall of the container through a plurality of the deforming spacers.

In any of the embodiments of Figs 15A-15E, any gap between the panel and the wall may be empty or filled, for example with foamed plastics either

granular or as a mass, fibrous material either loose or in mat or block form, or particulate materials, of which the simplest may be sand.